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(54) Rotary electric machine

(57) A slotless-core rotary electrical machine has a stator winding with conductors (1) enclosed in an insulating sheath (3). The conductors are arranged in three concentric layers (10, 11, 12) with the conductors of the inner layer (12) placed underneath every second conductor of the middle layer (11), and the conductors of the outer layer (10) placed over every other conductor of the middle layer (11). The central portions of the conductors are parallel to the machine axis and the end portions diverge therefrom. The end portions of the conductors of the middle layer (11) are bent from the axial direction by an angle which is half the size of the angle by which the end portions of the two other layers (10, 12) are bent. The conductors of the middle layer (11) are electrically connected in series and alternately to respective conductors of the outer and inner layers (10, 12).

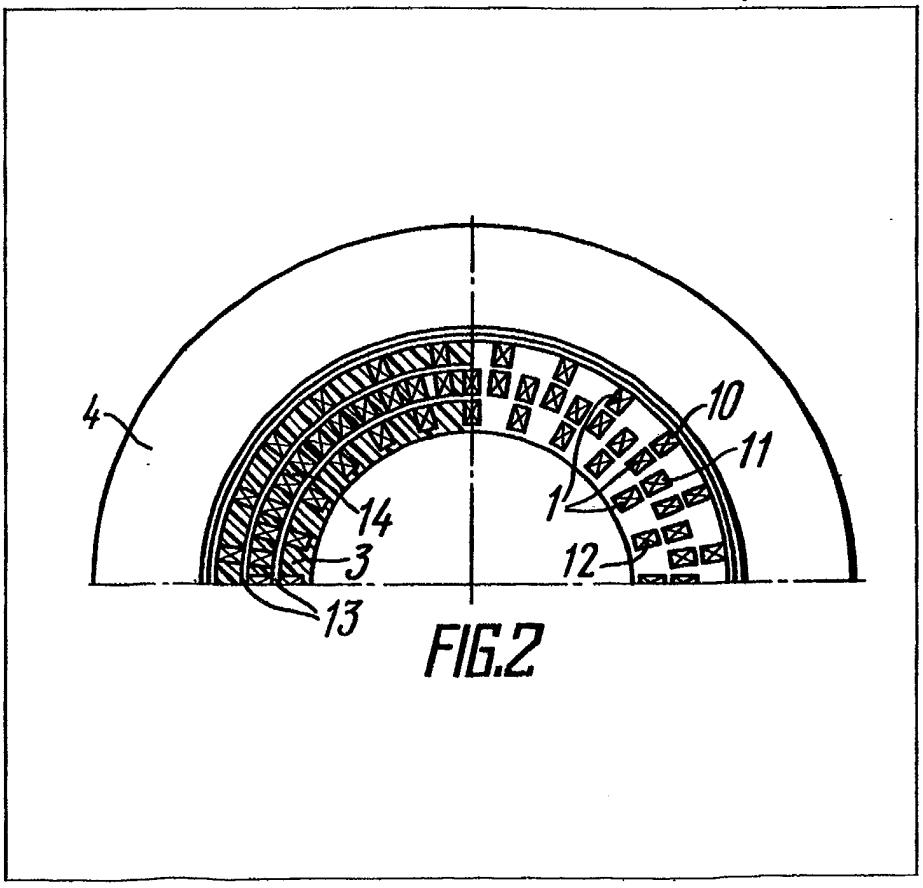

FIG.2

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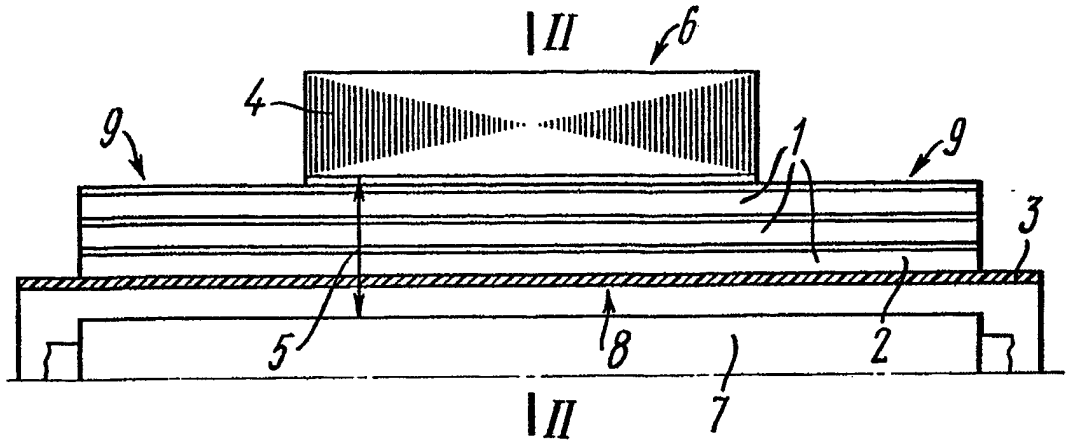


FIG.1

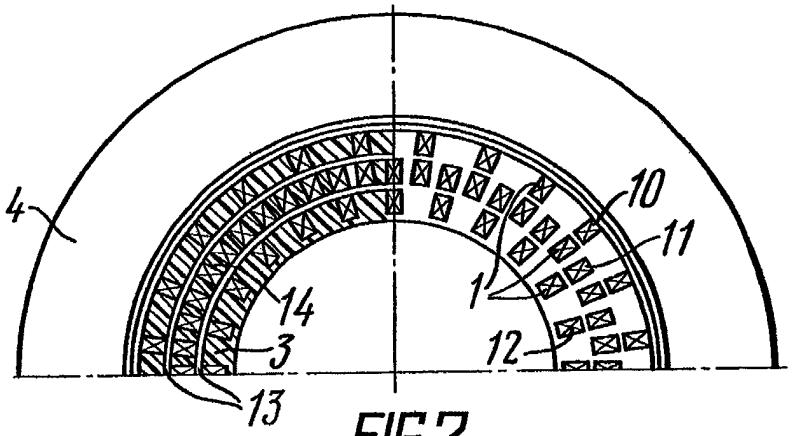


FIG.2

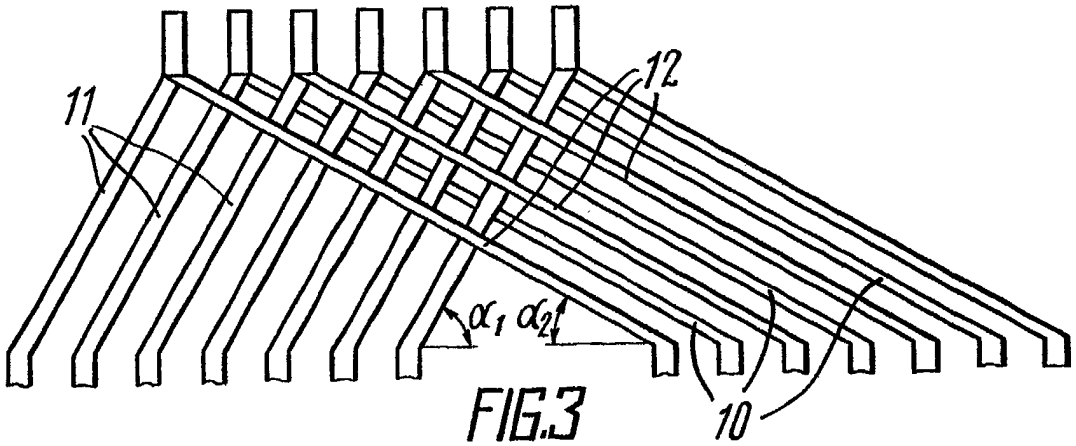
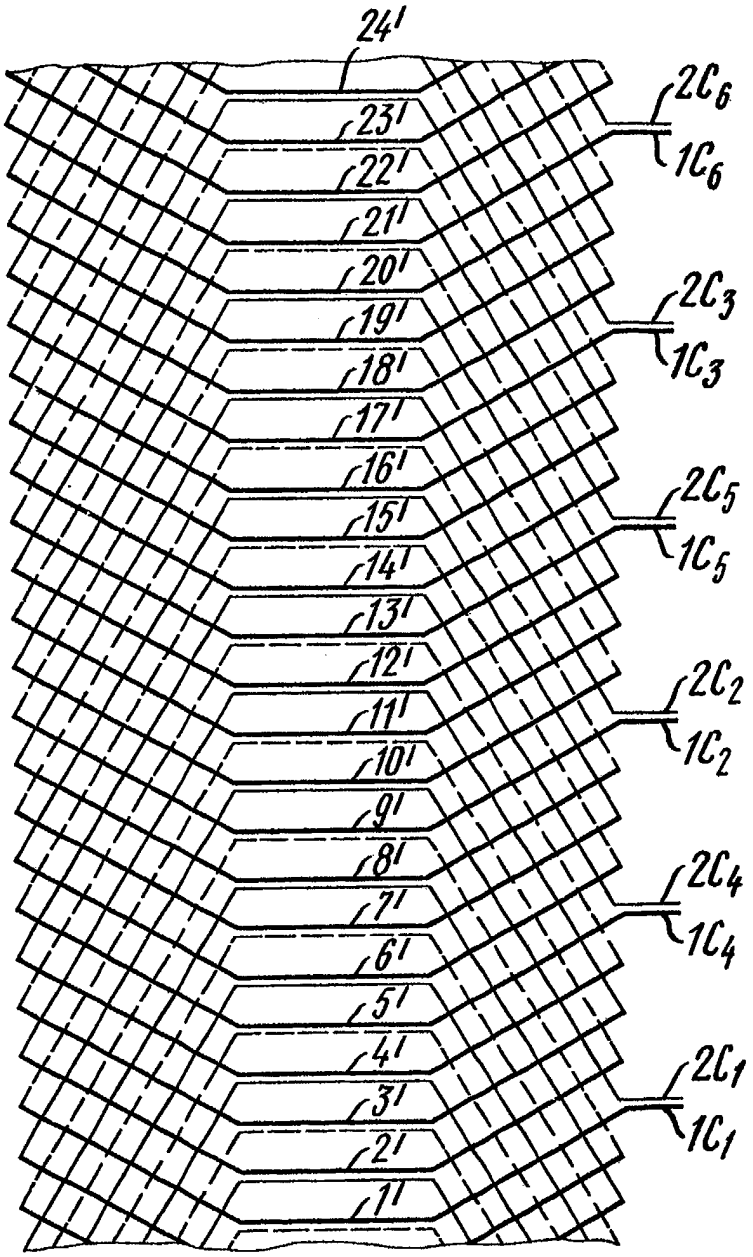


FIG.3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1C4
2C1
1C1

FIG.4

SPECIFICATION

Rotary electric machine

This invention concerns improvements in rotary electric machines.

According to the invention, there is provided a rotary electric machine having a stator winding formed in three concentric conductor layers in each of which each conductor has a portion extending parallel to the axis of the machine and on either side thereof a portion which diverges from the axis of the machine, the parallel conductor portions corresponding to the active portion of the stator winding and the diverged portions corresponding to the end portions thereof, the inner and outer layers of conductors having together the same number of conductors as the middle layer and, within the active portion of the stator, being arranged relative to the conductors of the middle layer such that the conductors of the inner and outer layers are radially aligned alternately with the conductors of the middle layer, the end portions of the conductors of the middle layer diverging from the machine axial direction by an angle α_1 which is approximately half the size of the angle α_2 by which the end portions of the conductors of the inner and outer layers diverge from the machine axial direction so as to provide for the connection of the conductors of the middle layer electrically in series with and alternately to the conductors of the other two layers.

In a preferred embodiment of the invention, the machine has a slotless stator core, and the windings are formed of electrically coupled conductors which are arranged in concentric layers and are parallel to one another in the active portion of the stator and inclined to the axial machine direction in the end portions. The conductors are accommodated in a sheath of electrically insulating material which is secured to the stator core and located in the air gap between it and the machine rotor. The conductors are arranged in three layers with the conductors of the inner layer being located radially underneath every second conductor of the middle layer and the conductors of the outer layer being located radially above every other conductor of the middle layer and the total number of conductors in the inner and outer layers is equal to the number of conductors in the middle layer. The end portions of the middle layer conductors are bent relative to their middle portions by an angle α_1 which is approximately half the corresponding angle α_2 by which the end portions of the conductors of the other two layers are bent relative to their end portions. The middle layer conductors are electrically connected in series alternately with respective conductors of the outer and inner layers.

The proposed stator winding arrangement provides for a less cumbersome electric machine having shorter end portions to the winding. At the same time the density of conductors in the active portion of the stator is increased by virtue of the increased [illegible] portions of the middle layer conductors are bent to a lesser angle than the conductors of the two other layers.

Other features and advantages of the present invention will become more apparent from the following detailed description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, wherein:

Figure 1 illustrates a longitudinal sectional view of a stator winding of a rotary electric machine according to the invention;

Figure 2 is a sectional view taken along the line II-II shown in Figure 1;

Figure 3 illustrates an exploded view of the end portion of a stator winding made up of three layers; and

Figure 4 illustrates a connection diagram of the stator winding of a rotary electric machine according to the invention.

Referring to Figures 1 and 2, the stator winding of an electric machine comprises electrically coupled conductors 1 having end portions 2 which are bent relative to the axial machine direction. The conductors 1 are accommodated in a sheath 3 of electrically insulating material such as glass fibre reinforced plastics which is secured to a slotless core 4 in an air gap 5 between the core 4 and the machine rotor 7. The sheath 3 can be formed as a solid unit featuring slots wherein the conductors 1 are later laid, or as shown in Figure 2 can be made sectional with the layers 10, 11 and 12 separated one from another by means of bindings 13 and with spacers 14 of electrically insulating material fitted between the conductors 1.

The conductors 1 have central active portions 8 and end portions 9 and are arranged in three concentric layers 10, 11 and 12. As shown in Figure 2, in the active portion 8, alternate conductors 1 of the middle layer 11 are each placed radially above a respective conductor 1 of the inner layer 12 and the other conductors 1 of the middle layer 11 are each placed radially underneath a respective conductor 1 of the outer layer 10. The number of conductors 1 in the middle layer 11 is equal to the total number of conductors 1 in the two other layers 10 and 12.

The central portions 8 of the conductors 1 are parallel to the machine axial direction and the end portions 9 diverge therefrom. The end portions 9 of the conductors 1 of the middle layer are bent by an angle α_1 (Figure 3) which is approximately half the size of the angle α_2 by which the end portions 9 of the conductors of the two other layers 10 and 12 are bent. As shown in Figure 3, the conductors 1 of the middle layer 11 are series connected alternately to the respective conductors of the two other layers 10 and 12 thus forming a lap circuit.

Referring now to Figure 4, there is shown the three-layer winding arrangement for a three-phase, two-pole electrical machine, comprising six coil groups $1C_1 - 1C_4$; $2C_1 - 2C_4$; $1C_2 - 1C_5$; $2C_2 - 2C_5$; $1C_3 - 1C_6$ and $2C_3 - 2C_6$. The conductors 1 (Figure 1) of the winding of the stator 6 in the active portion 8 are [illegible] in the air gap 5 of the electrical machine

24' (Figure 4).

The series of the conductors 1 (Figure 1) which is indicated by an even number will be referred to as even series. The words "even" and "odd" are used here only for convenience. In each coil group the conductors 1 of the middle layer 11 shown by continuous thick lines are alternately connected to the conductors 1 of the outer layer 10 shown by dotted lines and of the inner layer 12 shown by continuous thin lines.

Thus, for example, in the coil group $1C_1$ - $1C_4$ the conductor 1 of the series 1' of the middle layer 11 is connected to the conductor 1 of the series 11' located in the outer layer 10 of the winding, then it is further connected to the conductor 1 of the series 2' of the middle layer 11 and further to the conductors 1 of the series 12' located in the inner layer 10 of the winding, and so on.

Other coil groups $2C_1$ - $2C_4$; $1C_2$ - $1C_5$ etc. are formed in a similar way.

The end portions 2 (Figure 1) of the conductors 1 of the odd series 1', 3', 5' and others (Figure 4) are arranged in the outer layer 10 (Figure 3) of the winding in relation to the stator axis, the end portions 2 (Figure 1) of the conductors 1 of the even series 2', 4', 6' (Figure 4) and others are arranged in the inner layer 12 (Figure 3) of the winding in relation to the longitudinal axis of the stator, whereas the conductors 1 of the middle layer 11 of the winding are arranged both in the even and odd series.

The invention as herein described can provide a 20 - 30% reduction in the length of the end portions of the stator winding of a dynamo-electric machine as compared to known stator winding arrangements.

CLAIMS

1. A rotary electric machine having a stator winding formed in three concentric conductor layers in each of which each conductor has a portion extending parallel to the axis of the machine and on either side thereof a portion which diverges from the axis of the machine, the parallel conductor portions corresponding to the active portion of the stator winding and the diverged portions corresponding to the end portions thereof, the inner and outer layers of conductors having together the same number of conductors as the middle layer and, within the active portion of the stator, being arranged relative to the conductors of the middle layer such that the conductors of the inner and outer layers are radially aligned alternately with the conductors of the middle layer, the end portions of the conductors of the middle layer diverging from the machine axial direction by an angle α_1 which is approximately half the size of the angle α_2 by which the end portions of the conductors of the inner and outer layers diverge from the machine axial direction so as to provide for the connection of the conductors of the middle layer electrically in series with and alternately to the conductors of the other two layers.

2. A rotary electric machine as claimed in claim 1 wherein the stator windings in the active portion slotless stator core.

3. A rotary electric machine substantially as herein described with reference to Figures 1 to 3 or Figures 1 to 4 of the accompanying drawings.

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